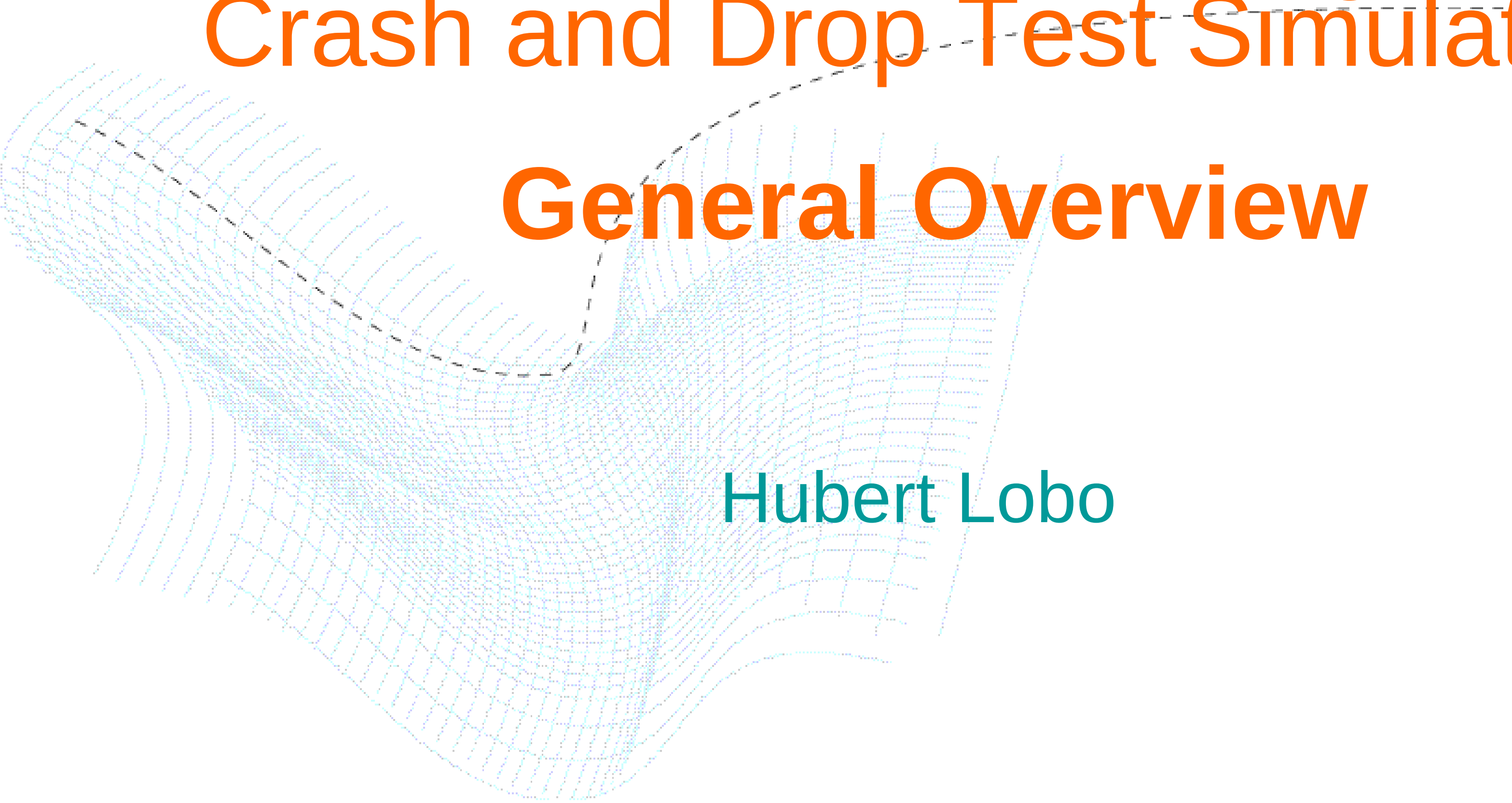
Material Modeling Strategies for Crash and Drop Test Simulation

General Overview



Hubert Lobo

DatapointLabs

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expert material testing

ISO 17025 Certified

Material Modeling Calibration Services

Since 1995

Expertise

- Since 1995
- Focus on product development / CAE
  - 25 CAE codes supported
  - ANSYS, LS-Dyna in-house
- >1,000 materials tested per year
  - Wide variety of materials
  - Over 200 types of physical properties

–Plastic
–Rubber
–Film
–Metal
–Foam
–Composite
–Cement
–Ceramic
–Paper
–Wire
–Fiber

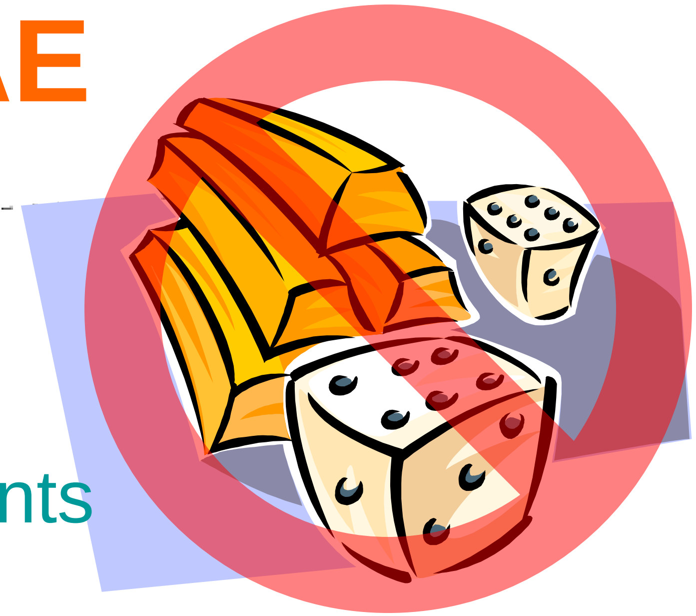
Market Base

- > 600 client companies
- Every manufacturing vertical
- Product development / R&D
- 90% US customer base
- Expanding to Europe/Asia
  - Seeking VARs / Resellers

- –Aerospace
- –Automotive
- –Appliance
- –Biomedical
- –Consumer products
- –Electronics
- –Materials
- –Pharmaceutical
- –Packaging

TestPaks® for CAE

- Simple to order
- Global availability
- Testing to CAE requirements
- Data in CAE-ready format
- Available via Matereality
- 120 material models supported



no gamble

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Objective

- Many LS-DYNA models used for plastics crash simulation
- Common models are not designed for plastics
- Develop best practices for adapting common LS-DYNA models to plastics

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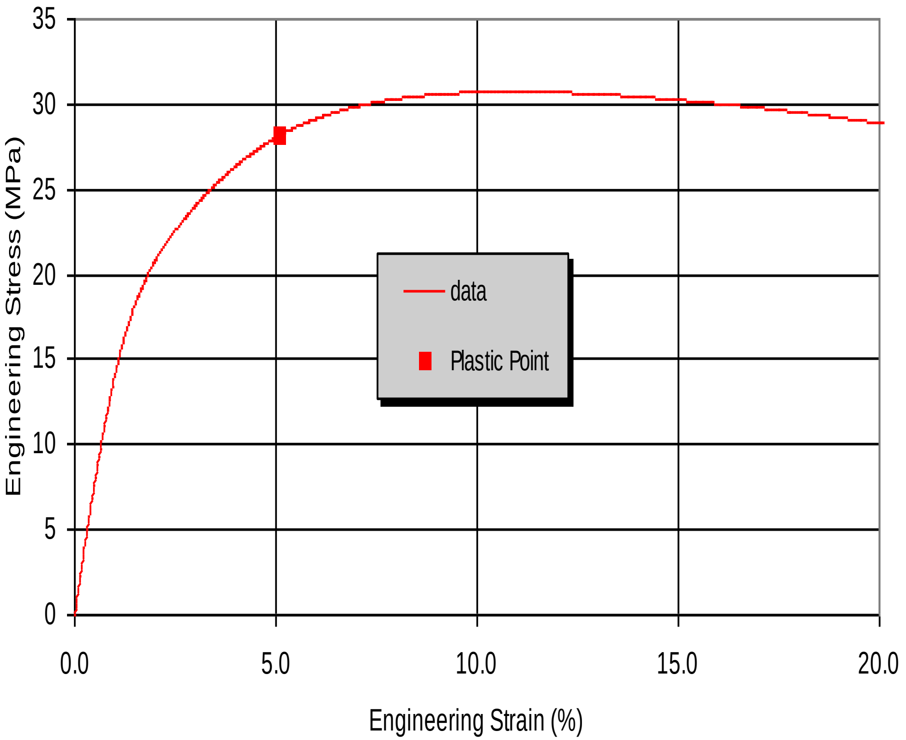
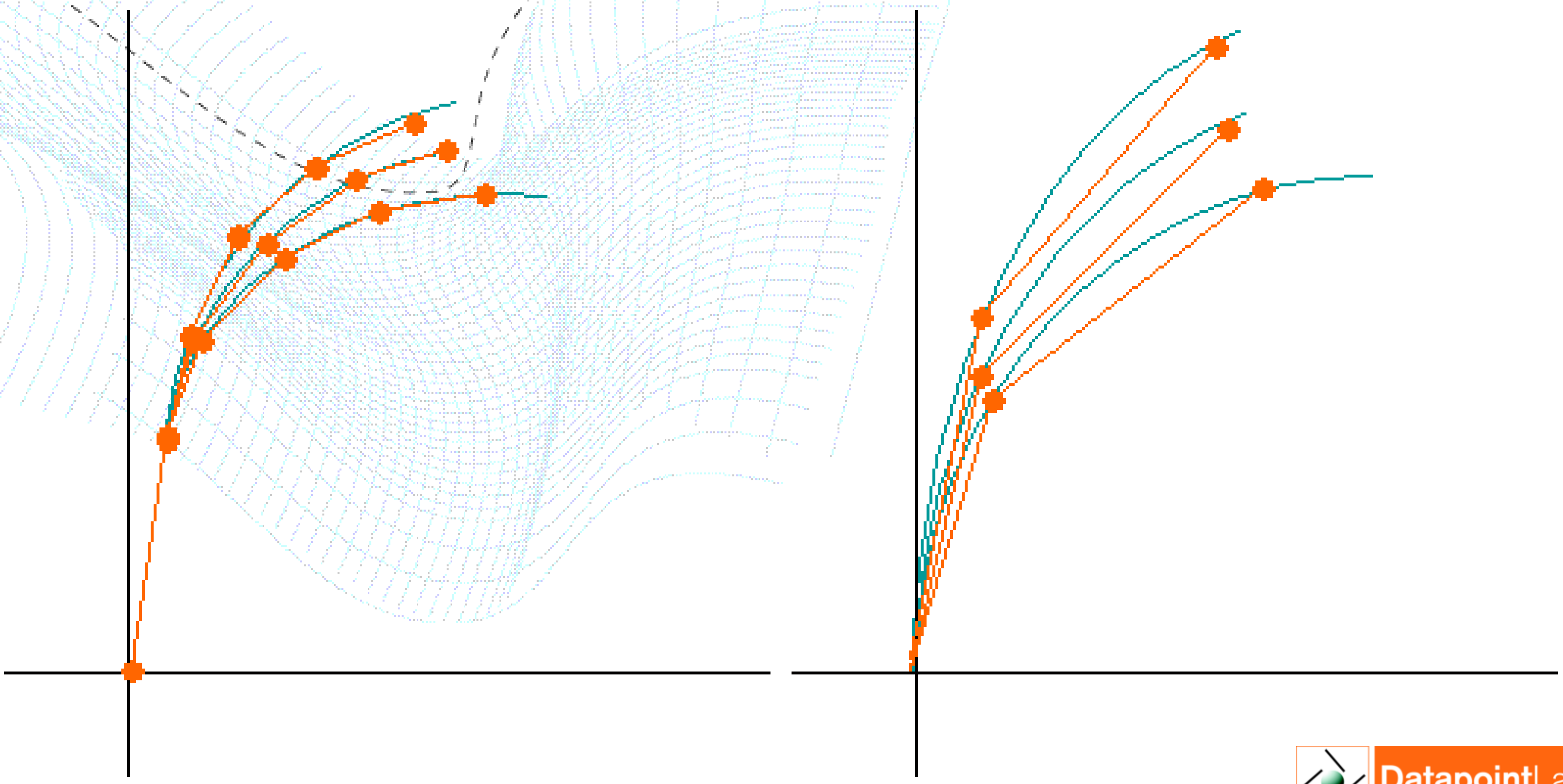
Plastics Behavior - Basics

- Non-linear elasticity
- Elastic limit well below classical yield point
- Significant plastic strains prior to yield
- Post-yield with necking behavior



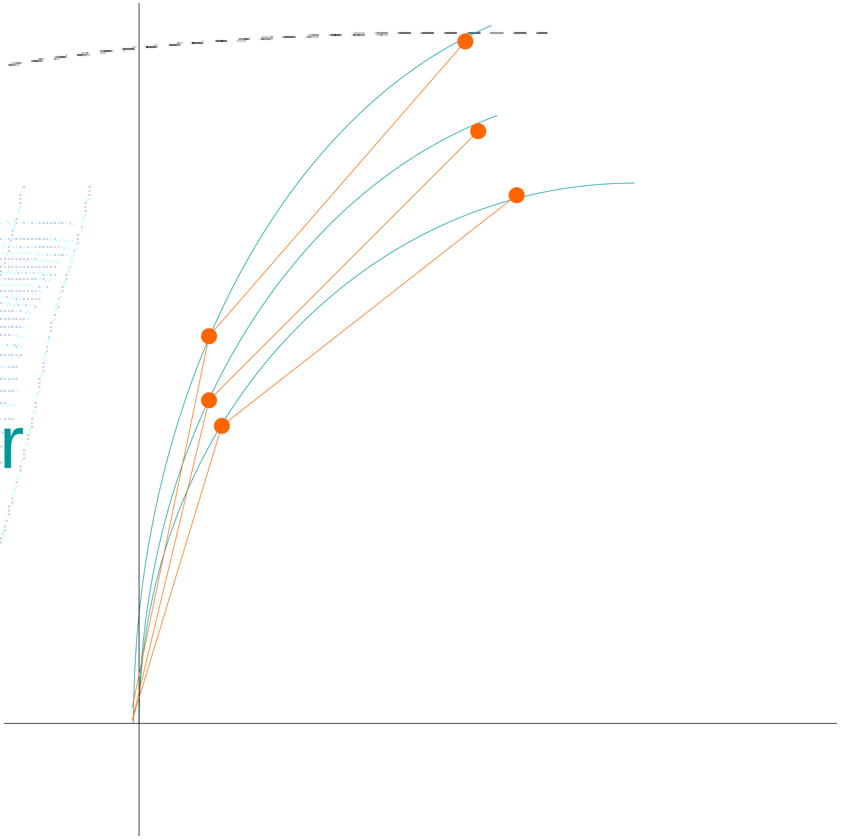
Plastics Rate Effects

- Modulus may or may not depend on rate



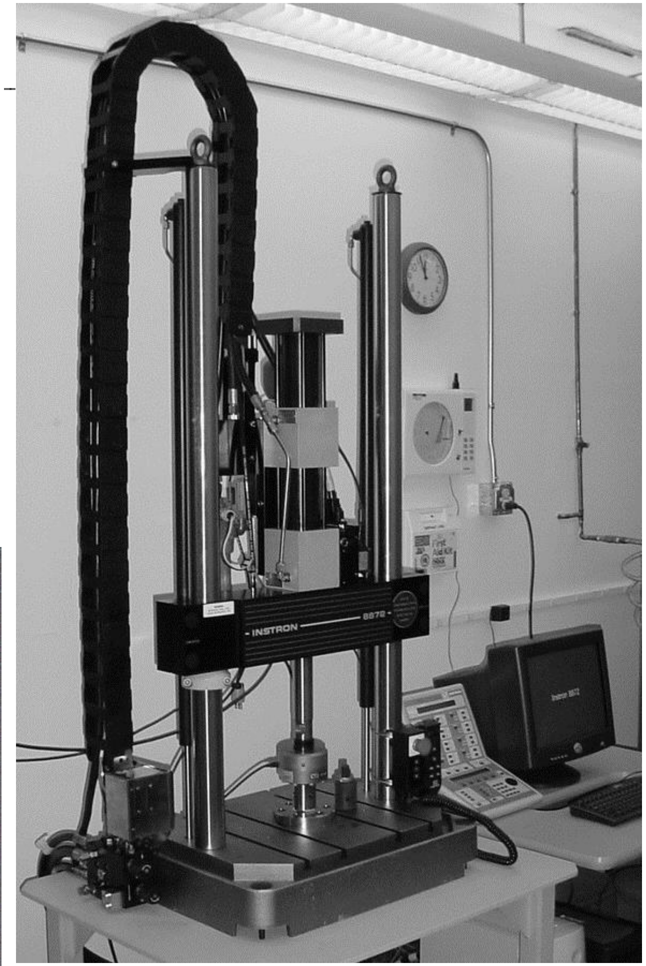
Effect of fiber fillers

- Higher modulus
- Small strain to failure
- Brittle failure
- No post-yield behavior
- Anisotropy



Material Testing

- Instron servo-hydraulic
  - Dynamic load cell
  - Tensile strain rate to 100/s
  - Tensile, compressive or flex



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MAT 24 – Ductile plastics

- Modulus is not rate dependent
- Large strains to failure
- Post-yield necking
- Plasticity curves vary with strain rate
- Failure strain independent of strain rate

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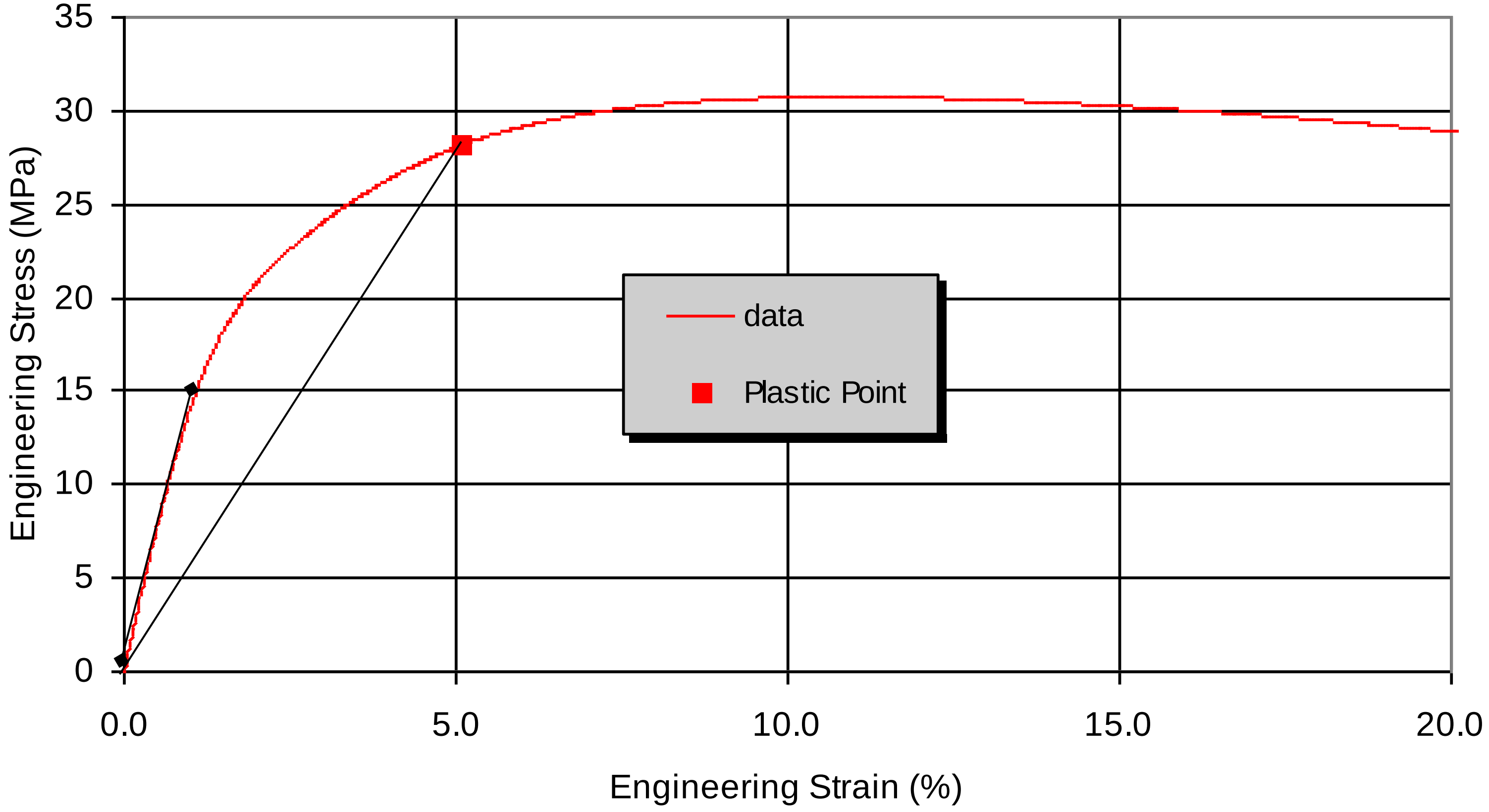
MAT 24 – Choosing EMOD



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MAT 24 – Plasticity

- Discretize curve
- Calculate EPS for each ES
- EPSmax > FAIL

(FAIL = element deletion strain)

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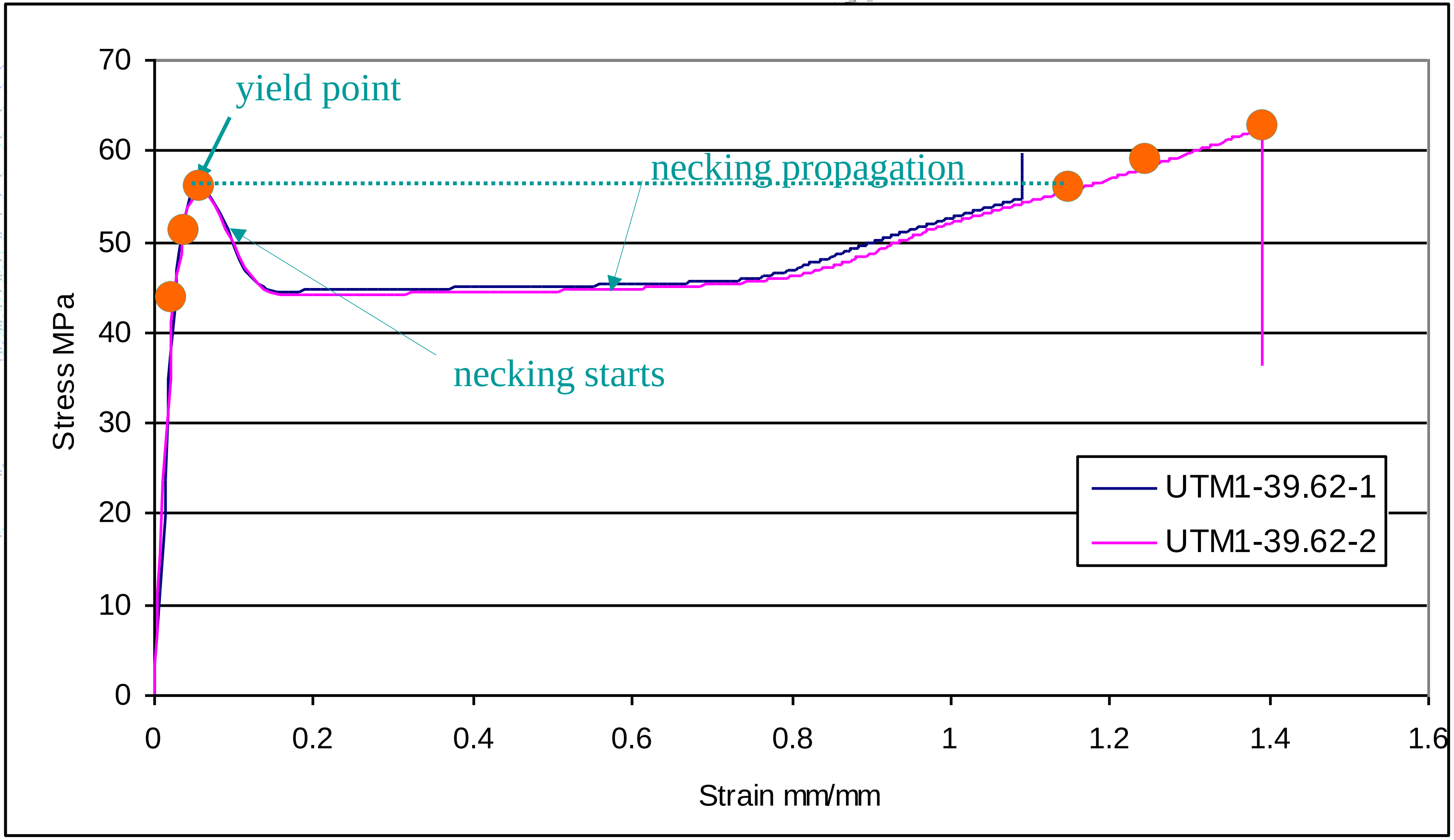
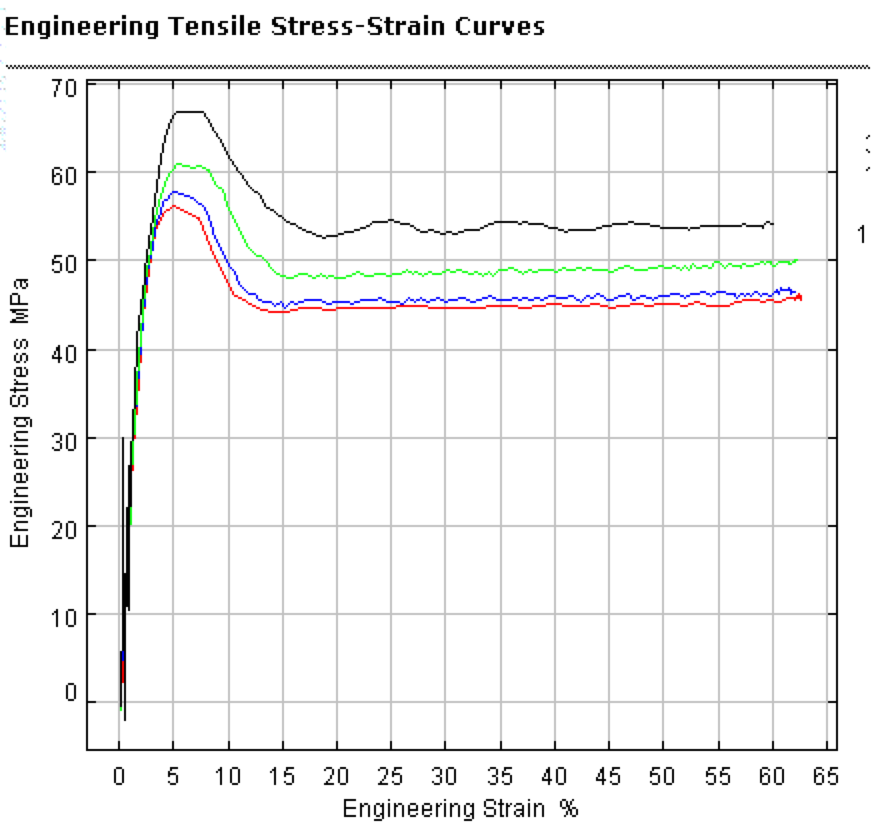
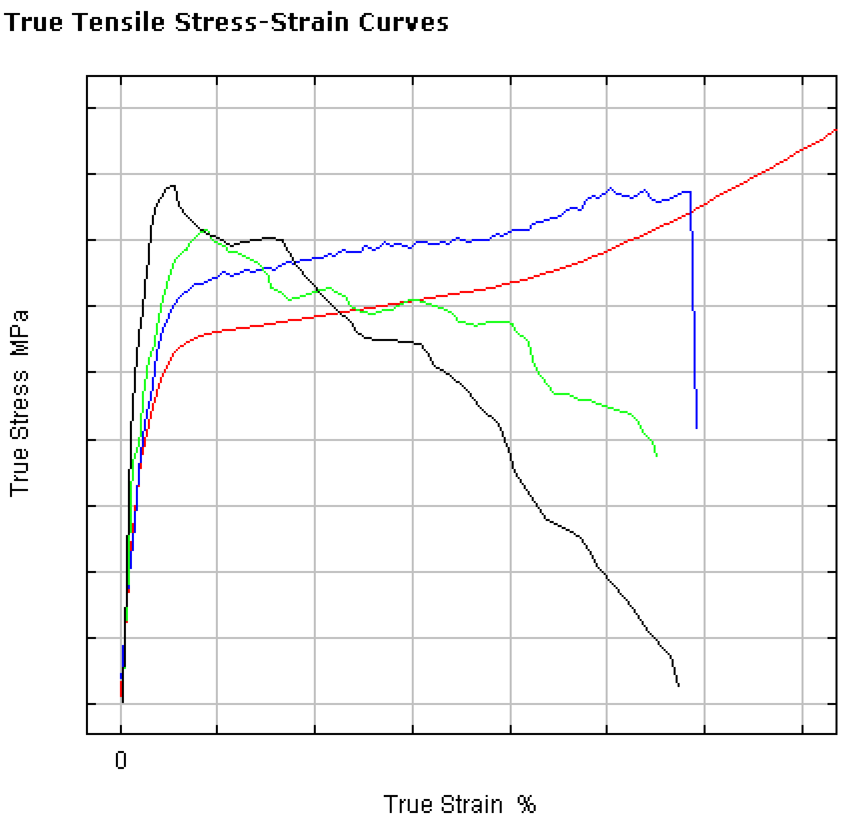
Post-yield with necking



MAT 24 – Fail Limitations

- When FAIL f(strain rate)





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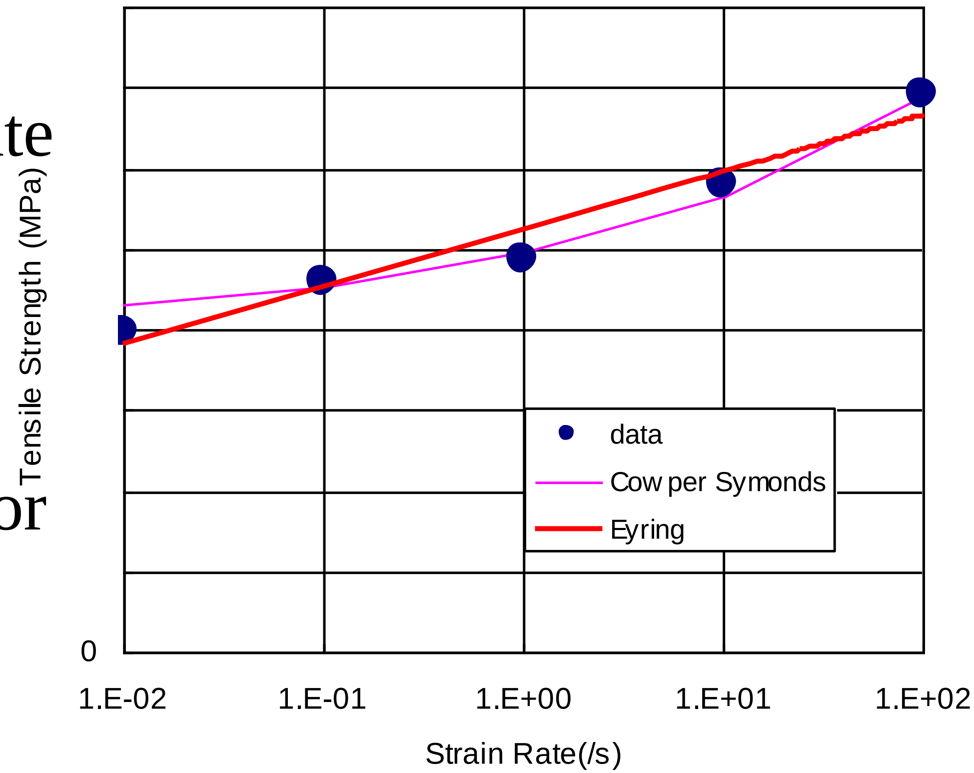
MAT 24 – Rate Dependency

- Cowper Symonds
  - Does not correlate well with plastics rate dependency
- LCSR
  - Capture model independent behavior



MAT 24 – LCSR-Eyring

- Eyring Model
  - Yield stress v. log strain rate is linear
  - Best form for plastics
- Fit yield stress v. log strain rate data to Eyring equation
- Submit as table using LCSR

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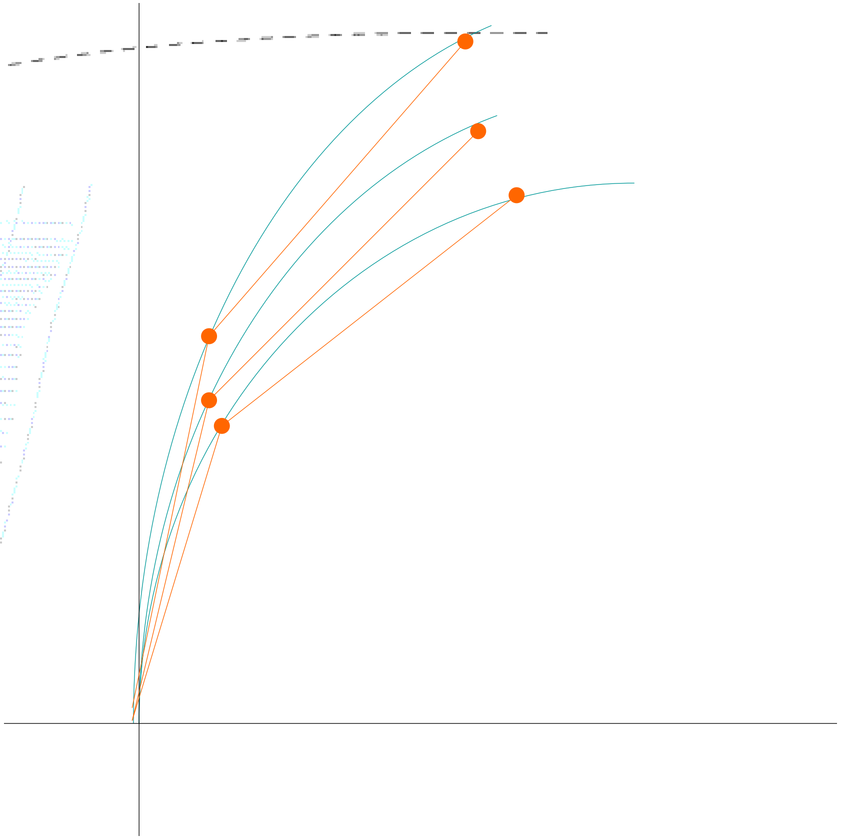
MAT 19 – Brittle plastics

- Modulus is rate dependent
- Small strains to failure
- Brittle failure
- Failure strain decreases with increasing strain rate

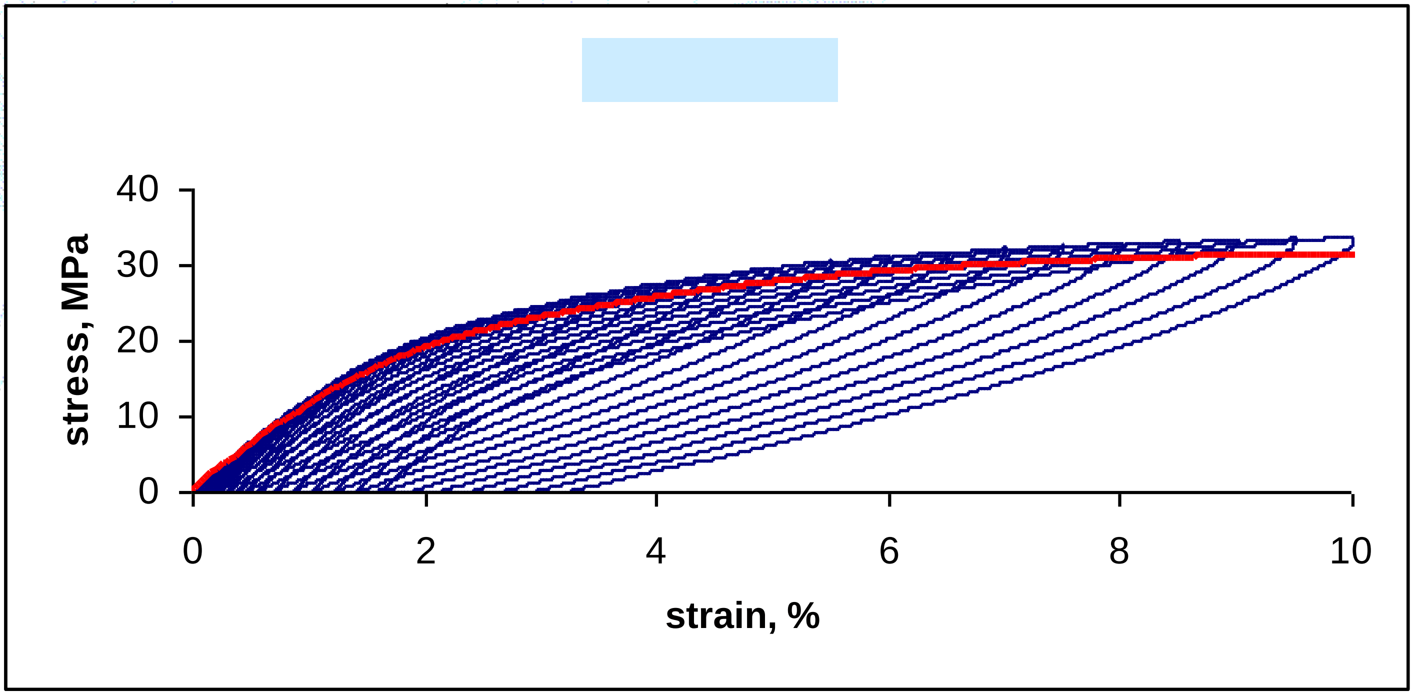
MAT 19 – Methodology

- Determine elastic limit at quasi-static strain rate
- Use elastic limit for von-Mises yield
- Define failure
  - failure stress v. strain rate table



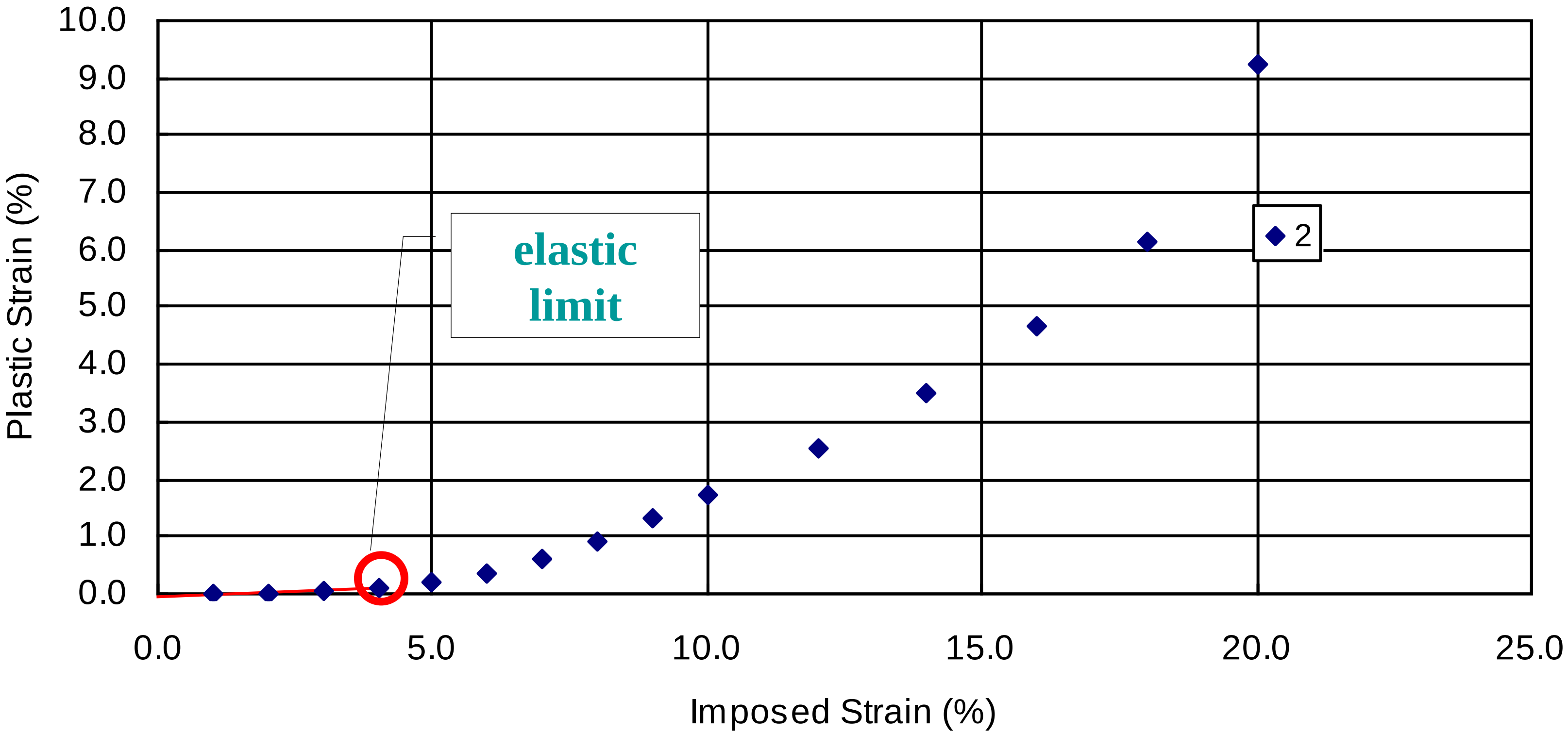
Finding the elastic limit

- Cyclic loading curves



Elastic Limit

- Residual v. imposed strain



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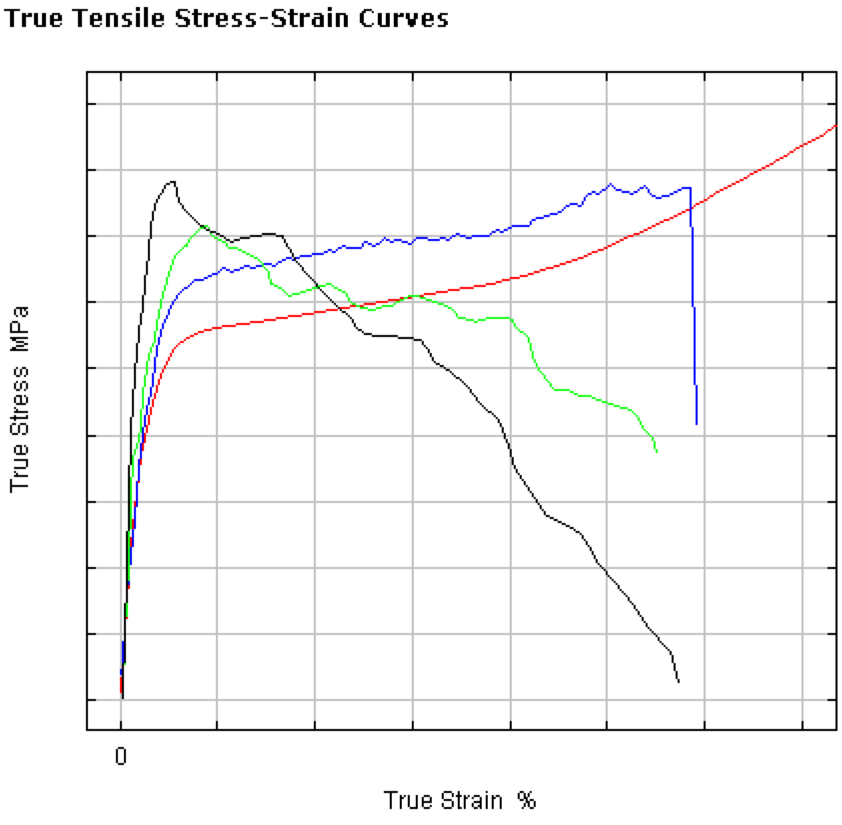
MAT 89 – Ductile-brittle

- Non-linear behavior
- Failure depends on strain rate
- Can handle ductile-brittle transitions
- Uses stress-strain curve



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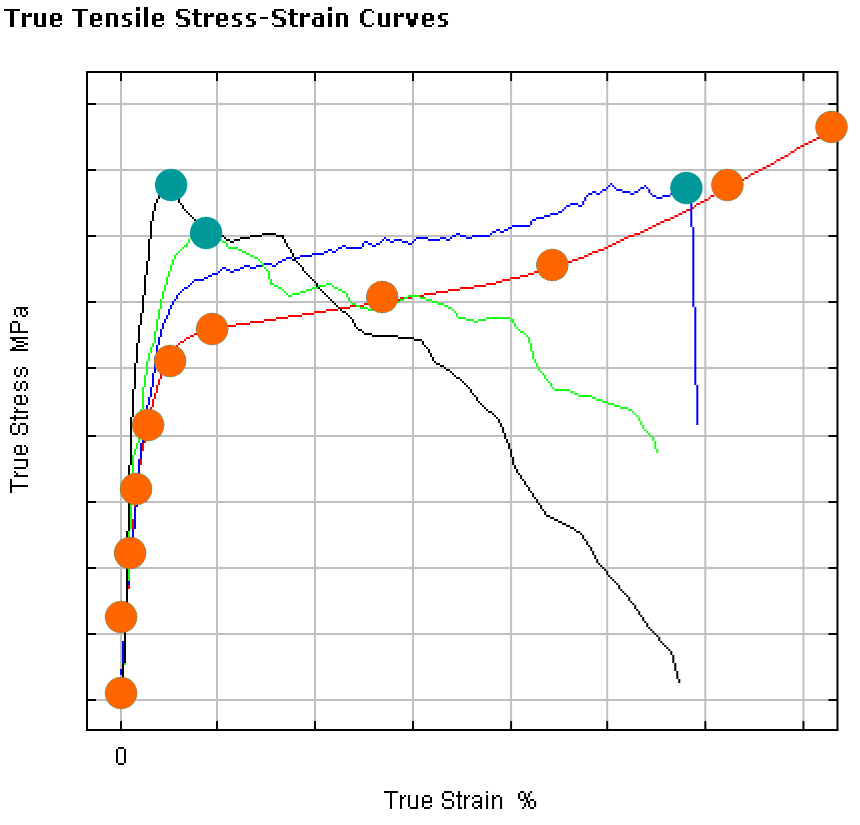
MAT 89 – Methodology

- Submit stress-strain curve ●
- Submit EMOD
- Submit rate dependency via LCSR-Eyring
- Submit failure strain v. strain rate via LCFAIL ●



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MAT 89 – Workings

- Internally decompose quasi stress-strain curve
  - Use EMOD for von Mises limit
  - Rest of the curve is elastic-plastic
  - Rate dependency via LCSR
  - Failure via LCFAIL

Conclusions

- Choice of material model depends on
  - Material
  - Test data
- Proper selection = reasonable model
- Simple improvements can add power

Questions? go to *testpaks.com*

- CAE centric materials web-site
- Focus on material modeling
- Testing for CAE
- Supported by
  - DatapointLabs
  - CAE vendors
  - Expert users

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